Figure I-2-7. Hallandale Beach, an example of a popular recreation beach in an urban area on the Atlantic coast of southeast Florida. Photograph taken June 27, 1991, after the beach had been renourished using sand hydraulically pumped from an offshore source. Stakes in the beach were used as survey markers

geomorphology is evident. Despite the presence of a series of regional mountain ranges that cut across the coast, the rugged central and northern California coast is one of the straightest in the world. This area has high cliffs with raised marine terraces. A few broad river valleys interrupt the mountainous coast. Here, river sediments have been returned by the waves to the beaches and carried inland by westerly winds to form some unusually large dune fields. Monterey and San Francisco Bays, the two largest embayments, are at the mouths of the Salinas and the San Joaquin-Sacramento rivers respectively; the latter drains the great central valley of California. North of Cape Mendocino, the coast trends almost directly north, through Oregon and Washington, to the Strait of Juan de Fuca. Along this coast, lowland valleys at the mouths of large rivers alternate with short, relatively low mountainous tracts. Barriers or spits have formed at river mouths, as have large dune fields (Figure I-2-16). Many of the rivers, including the great Columbia, discharge into estuaries. This indicates that the rivers have not yet been able to fill drowned valleys created by the sea level rise when the great Pleistocene continental glaciers melted (Shepard 1982).

Because of the North Pacific Ocean's harsh wave climate, all of the major cities in Oregon and Washington were founded in sheltered water bodies. For example, Vancouver, Washington, and Portland, Oregon, are on the Columbia River. Puget Sound, a deep, sheltered, fjord-like water body in western Washington State, provides safe access for ships steaming to Tacoma, Bellingham, Everett, and Seattle (Figure I-2-17).

g. The Bering and Chukchi Seas: Arctic coastal plains and barriers (Figure I-2-18). The volcanic Aleutian Mountains trend southwest from Anchorage, Alaska, to form the Alaska Peninsula and the Aleutian Islands that extend some 2200 km (1370 miles) forming the border between the Pacific Ocean and the Bering Sea (Figure I-2-14). Beyond the Alaska Peninsula and bordering the Bering Sea, extensive coastal plains

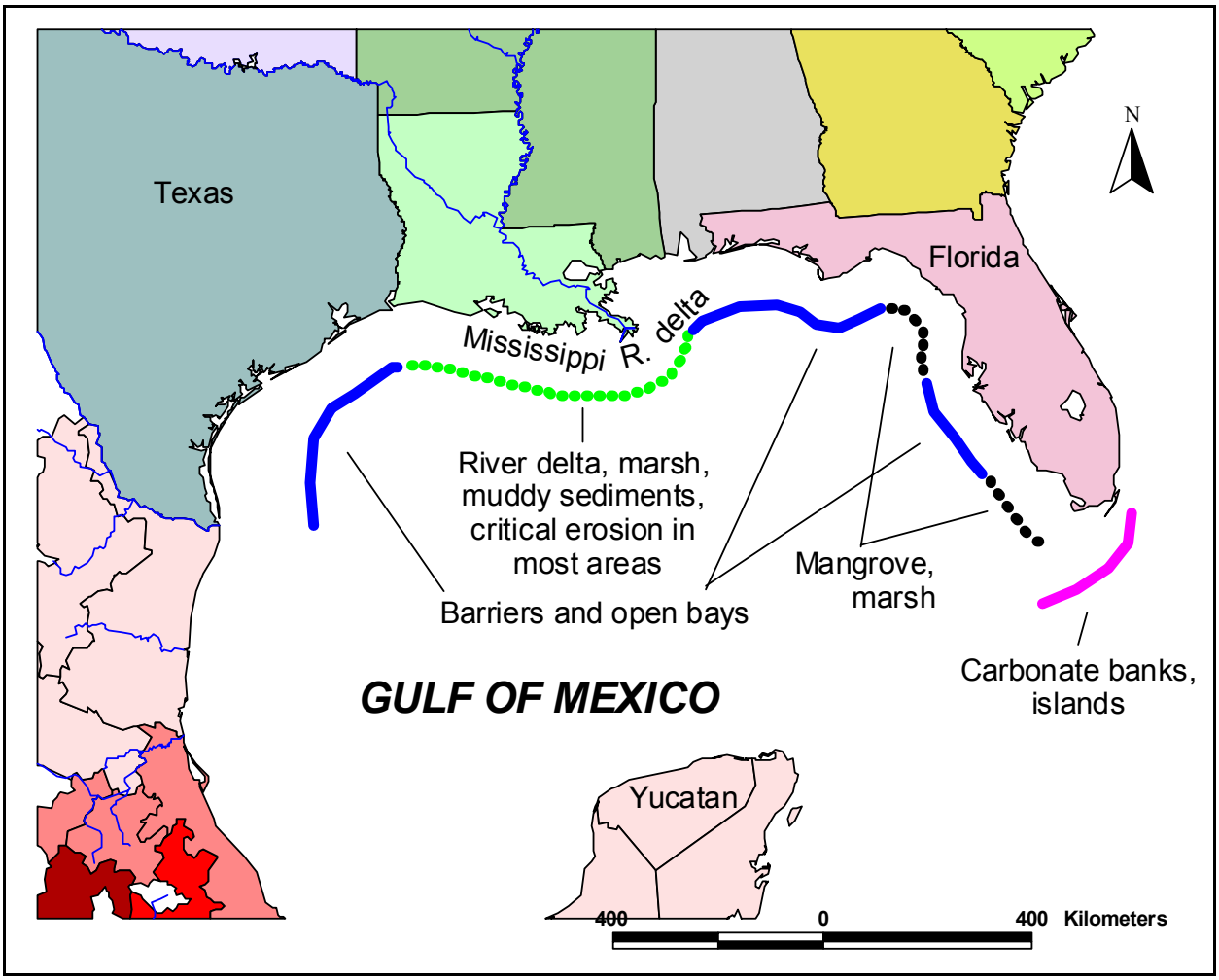

Figure I-2-8. Gulf of Mexico coastal characteristics

are found with numerous lakes and meandering streams. Only a few mountain ranges extend as points into the sea. The Yukon River has formed a large delta with many old lobes that form a vast plain connecting small, elevated tracts. The oldest is located in the now drowned mouth of the Kuskokwim River. One reason this coast differs from the glaciated southern coast of Alaska, is because it was largely ice- free during the Pleistocene era. Permafrost becomes more important to the north where it greatly increases the number of surface depressions in the summer when it melts forming *thaw lakes.* Rising above the coastal plain with mountains over 1,000 m, the Seward Peninsula with Norton Sound and the Bering Sea to the south and Kotzebbue Sound and the Chukchi Sea to the north provides a great contrast to the adjoining coasts. North of Kotzebue Sound, barriers and cuspate forelands similar to those of North Carolina border the coast. The first cuspate foreland is the unusual Point Hope. Three more cuspate forelands extend along the coast terminating with Point Barrow, the most northern point of Alaska (Shepard 1982).

h. The Beaufort Sea: Deltaic coast. East of Point Barrow, the coast is dominated by river deltas. Rivers draining the Brooks Range and father east the Mackenzie, draining the northern Canadian Rockies, built these deltas even though the rivers flow only a short period each year. Where the deltas are not actively building into the sea, extensive barrier islands can be found (Shepard 1982). One of the dominant processes in shaping beaches in Alaska is the ride-up of shore ice (Kovacs 1983).

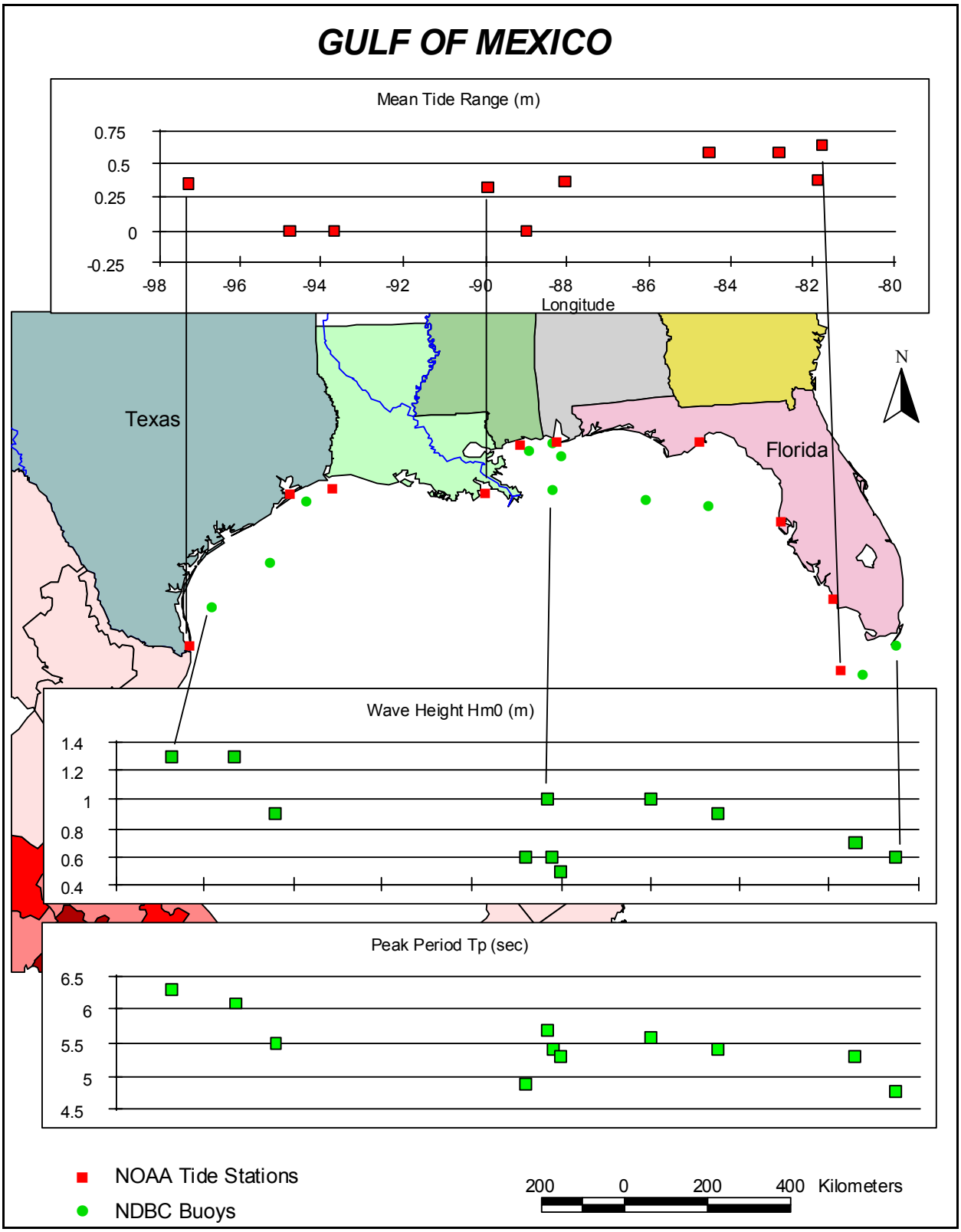

Figure I-2-9. Tide and wave characteristics of the Gulf Coast

Figure I-2-10. East Pass Inlet, Florida, View looking west towards Santa Rosa Island, with the Gulf of Mexico on the left and Choctawhatchee Bay to the right. The barrier island immediately beyond the inlet is part of Eglin Air Force Base and has remained undeveloped. The beach in the foreground is Holiday Isle, which has been heavily commercialized. This area of Florida is noted for its brilliant white quartz sand and excellent fishing. The inlet is a Federal navigation project with converging rubble-mound jetties. Photograph taken March 1991

i. Pacific: Volcanic islands (Figure I-2-19). The Hawaiian archipelago extends from the large island of Hawaii across the central Pacific Ocean northwest to tiny Kure Atoll, 2450 km away. The eight main islands of the state of Hawaii, at the southeast end of the archipelago comprise 99 percent of the land area. About 20 percent of the 1,650 km of shore on the main islands is sandy beach (USACE 1971). Aside from manmade structures, the remainder of the shore consists primarily of outcrops or boulders of lava, but also includes muddy shores, gravel beaches, beach rock, raised reefs, and lithified sand dunes. Elevations of the rocky shores vary from 1-2 m high raised reefs to 600 m sea cliffs along the Napali coast of Kauai. The Hawaiian Islands are the tops of volcanic mountains rising above the ocean floor about five km below the water surface. These volcanoes formed over a localized hot spot of magma generation. As the older volcanoes formed great shields and died, the movement of the ocean floor and crust moved them to the northwest. A higher percentage of sand shores are found on the older islands, see Table I-2-1. Beaches on Hawaiian Islands are smaller than those on the continental shores, because of the young age of the islands, the absence of large rivers to supply sediment, and the shape and exposure of the island beaches to the wave systems that affect the islands. The sand on the beaches is also different in that it is primarily calcareous and of biologic origin. The calcareous sand originates as shells and test of animals or algae that live on the fringing reefs or shallow waters adjacent to the islands. Two exceptions are some beaches near stream mouths are detritus basalt sand, and a few beaches on the island of Hawaii are black volcanic glass sand generated by the steam explosions that occur when hot lava flows into the ocean (Moberly and Chamberlain